Integrating Systems Engineering Concepts into Transportation Research, Education, and Practice

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Systems Engineering: a definition and some concepts

- **Systems Engineering /** an interdisciplinary **process** that ensures that the customer's **needs** are satisfied throughout a system's entire **life cycle.**
- **Define the Problem /** identifying customers/**stakeholders**, understanding customer **needs**, defining **system requirements and system functions.**
- **Articulate Objectives /** determining what will be achieved
- **Formulate and Evaluate Alternatives**/develop concept of operations plan, architecture and model system
- **Integrate** requires extensive wire and wireless communication, interfaces, and coordination.
- **Deploy the system /** means implementing the system, producing outputs, outcomes (+ and - ?)
- **Assess performance and re-evaluate /** employ quantitative/qualitative measures

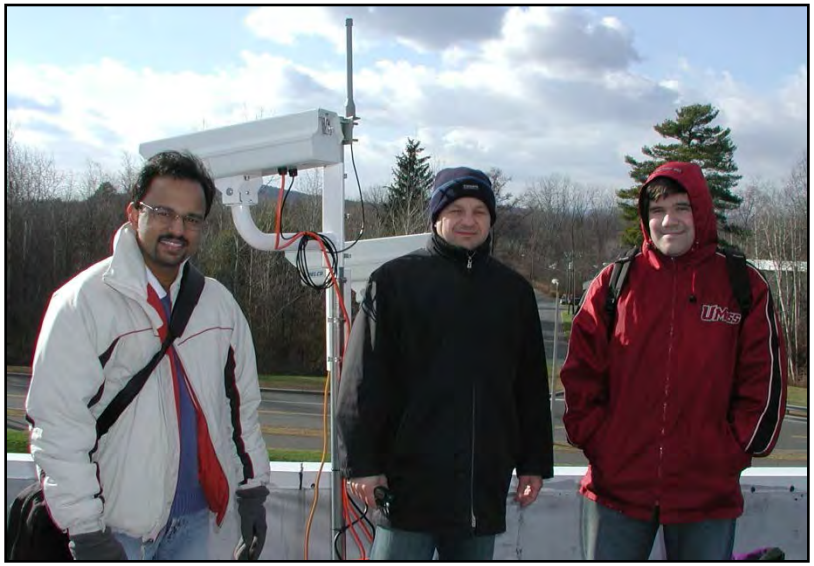
Regional Traveler Information Center (RTIC)

- Transportation research, educational, and deployment initiative at the University of Massachusetts Amherst serving the 5 College Area (UMass, Amherst College, Hampshire College, and Mount Holyoke College, and Smith College)

- Collaborative venture including Umass Transportation Center, UMass Transit Services, U.S. DOT, and MassDOT

RTIC as a Research and Teaching Laboratory

- ITS field lab for University Transportation Studies
  - Source of traffic data
  - Real-life ITS experience
  - Research opportunities
  - New technologies



RTIC's Objectives

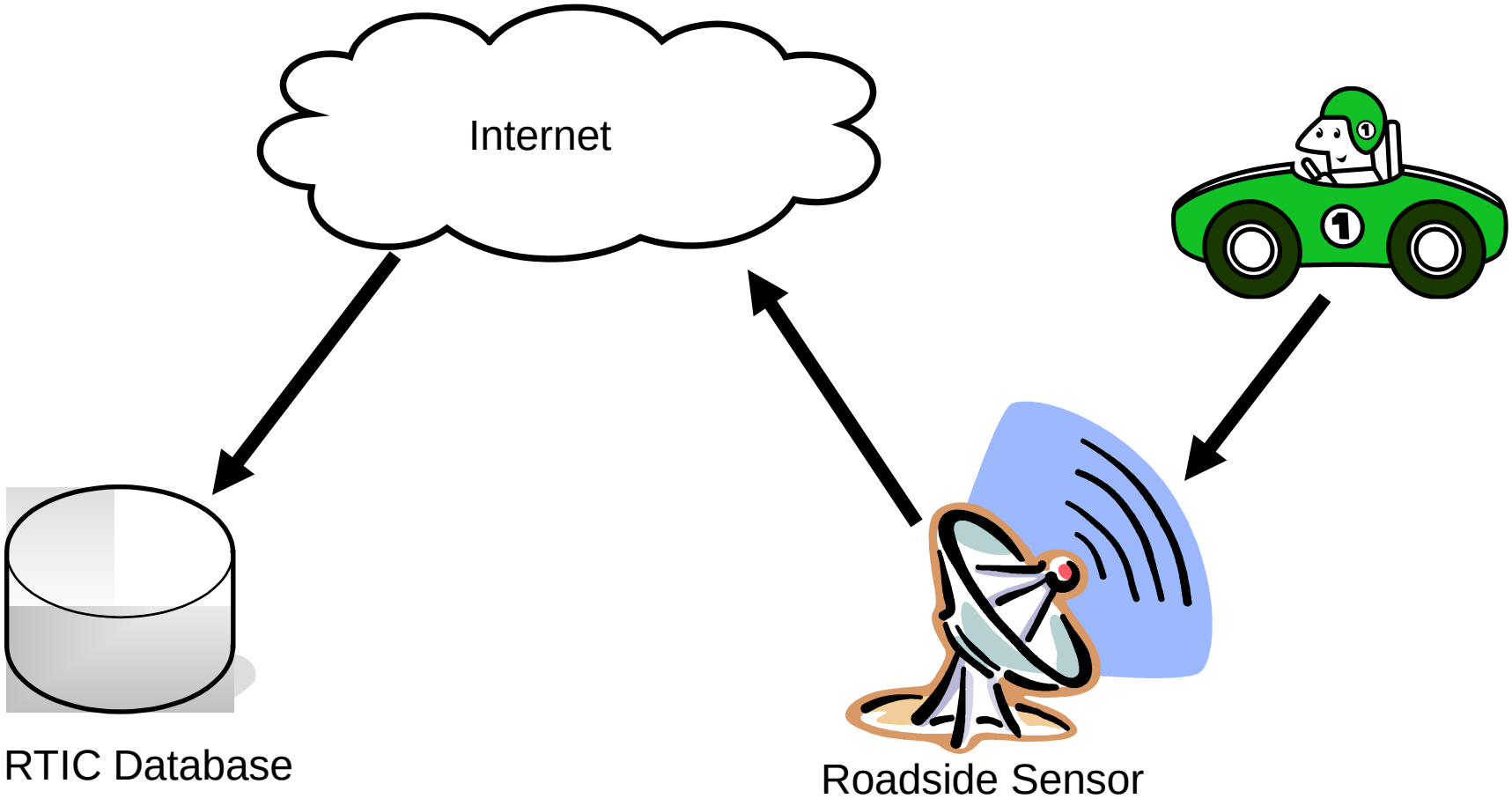
- Establish Transportation Database
  - Collection
  - Analysis
  - Dissemination
- Provide Highway Travel Advisories
  - Construction
  - Road closures
- Provide Public Transit Advisories
- Support academic activities

Traffic camera and license plate reader system

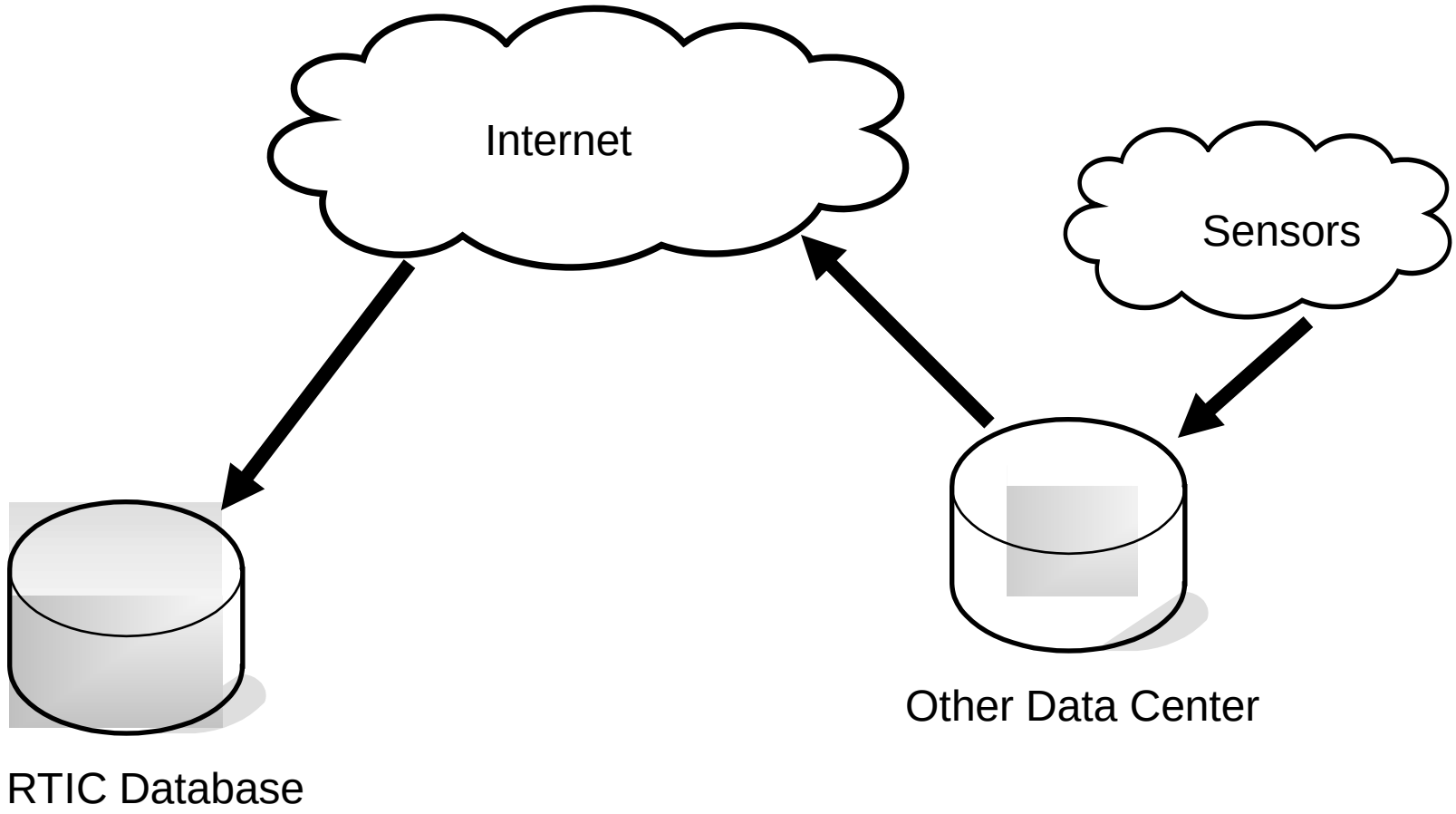
ITS National System Architecture (aka Sausage Diagram)

- The diagram depicts the basic communication channels between the subsystems.
- The subsystem diagram is a top-level architecture interconnect diagram.
- Variations of the subsystem diagram are sometimes used to depict regional ITS architectures or project ITS architectures at a high level.

Roadside to RTIC



Center to Center



Traffic Cameras

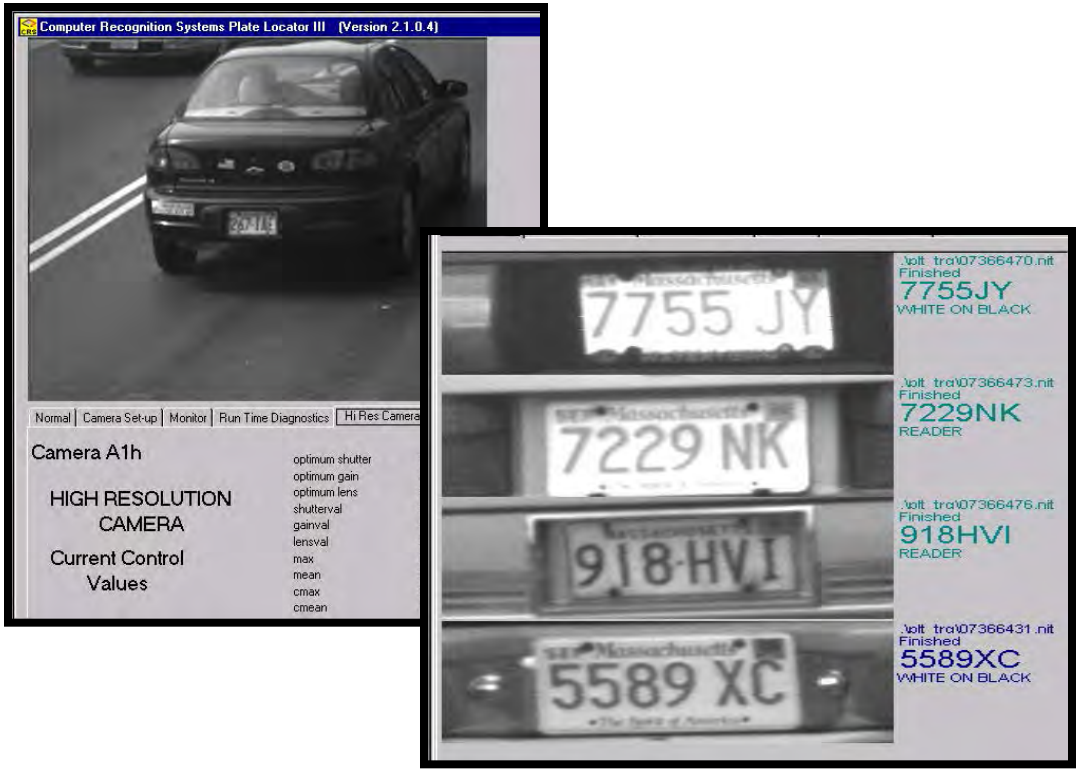
- Network enabled cameras
  - Dial up
  - Ethernet
  - Wireless
- Most popular RTIC resource

License Plate Recognition Challenges

- Privacy!!!
- Illumination
- Computationally expensive
- Massachusetts plates
- Occlusion
- Bumper stickers

Travel Time Estimation

- License plate reader
- Electronic toll collection tags



License Plate Recognition Challenges

- $$$
- Privacy
- Illumination
- Computationally expensive
- Massachusetts plates
- Occlusion
- Bumper stickers

Travel Time Estimation Using FASTLANE Tags

- Tag is programmed with station number and timestamp at each reader station.
- System calculates travel time between previous and current station.

Travel time of 25 minutes from Station 1 to Station 2

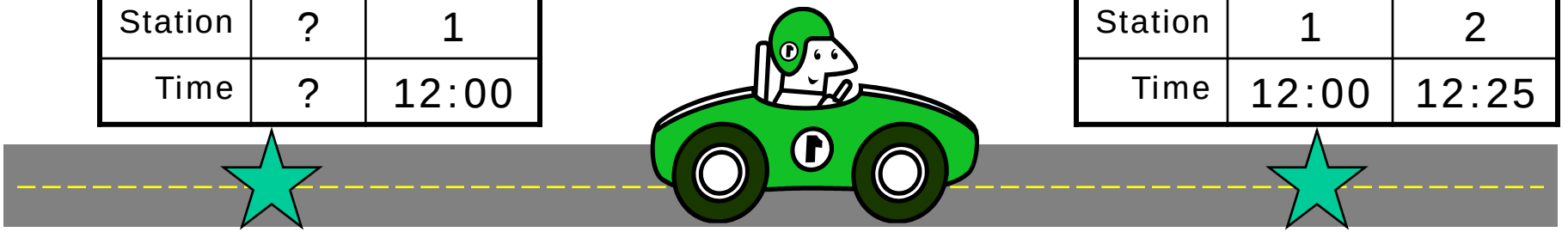
No personal or uniquely identifiable information collected!

Station 1

	read	written
Station	?	1
Time	?	12:00

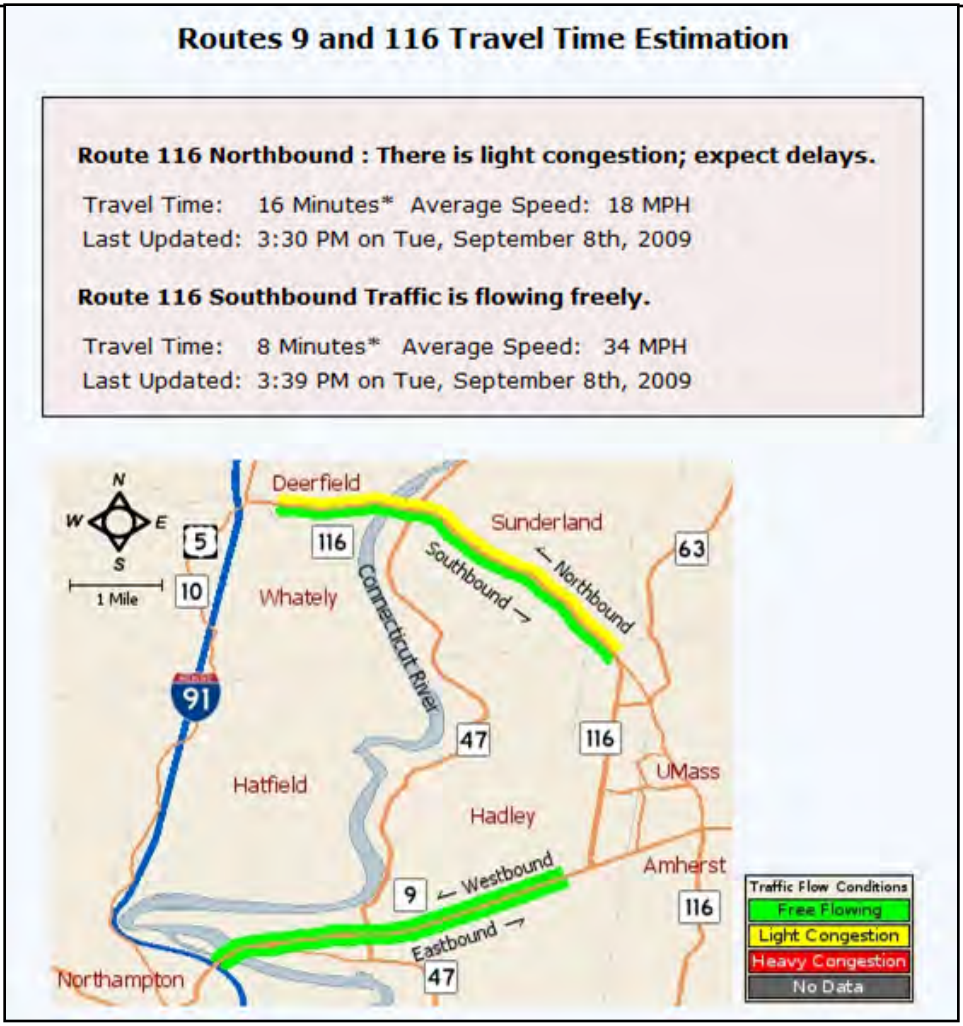
Station 2

	read	written
Station	1	2
Time	12:00	12:25

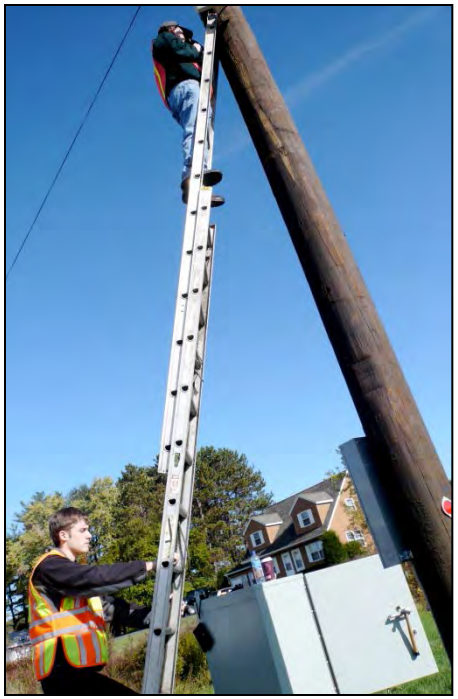


FastLane Travel Time Estimation

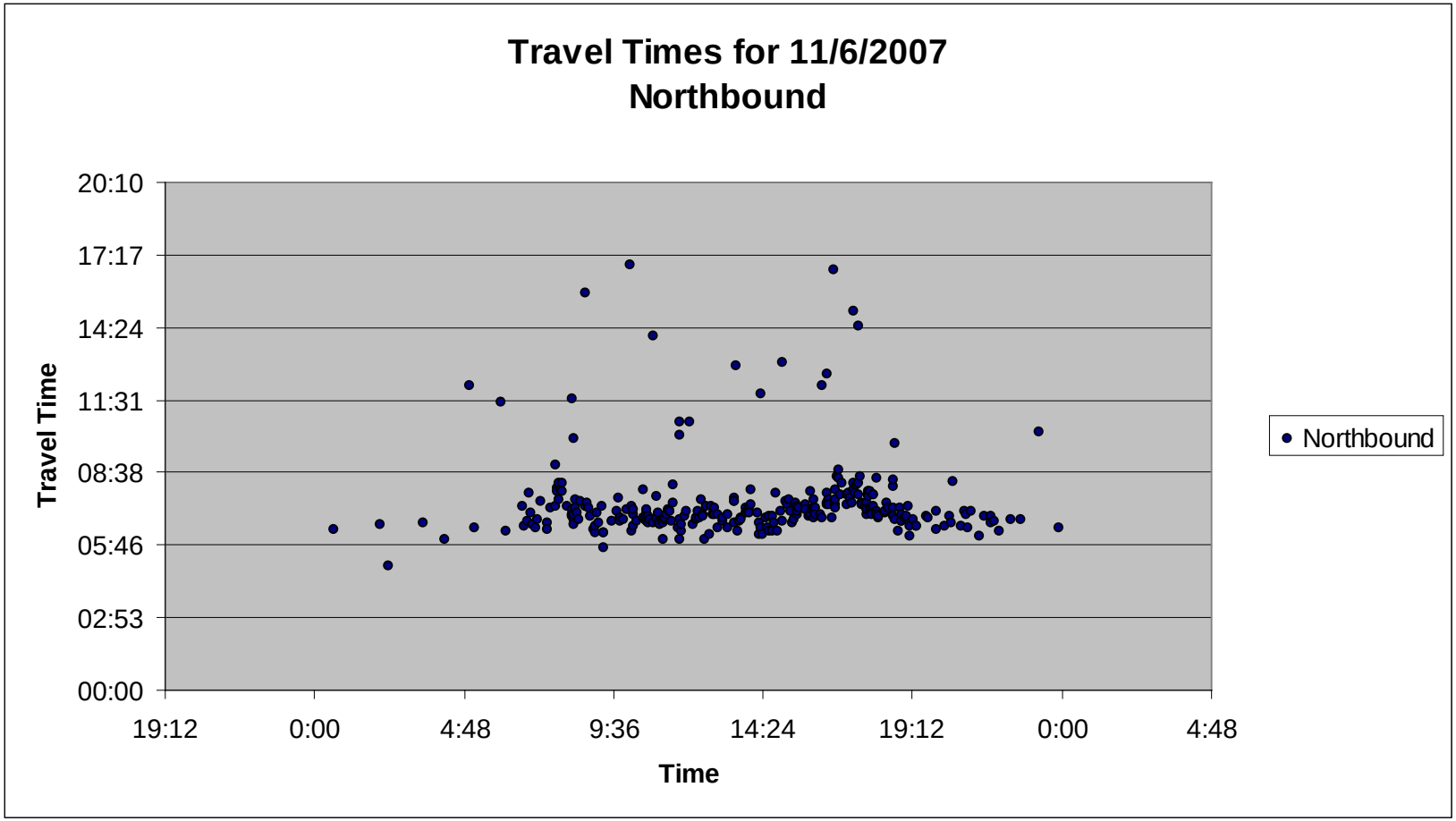
- Route 116 launched September 1st, 2007
- Route 9 launched September 1st, 2009
- 24,209,957 tags
- 3,822,659 journeys



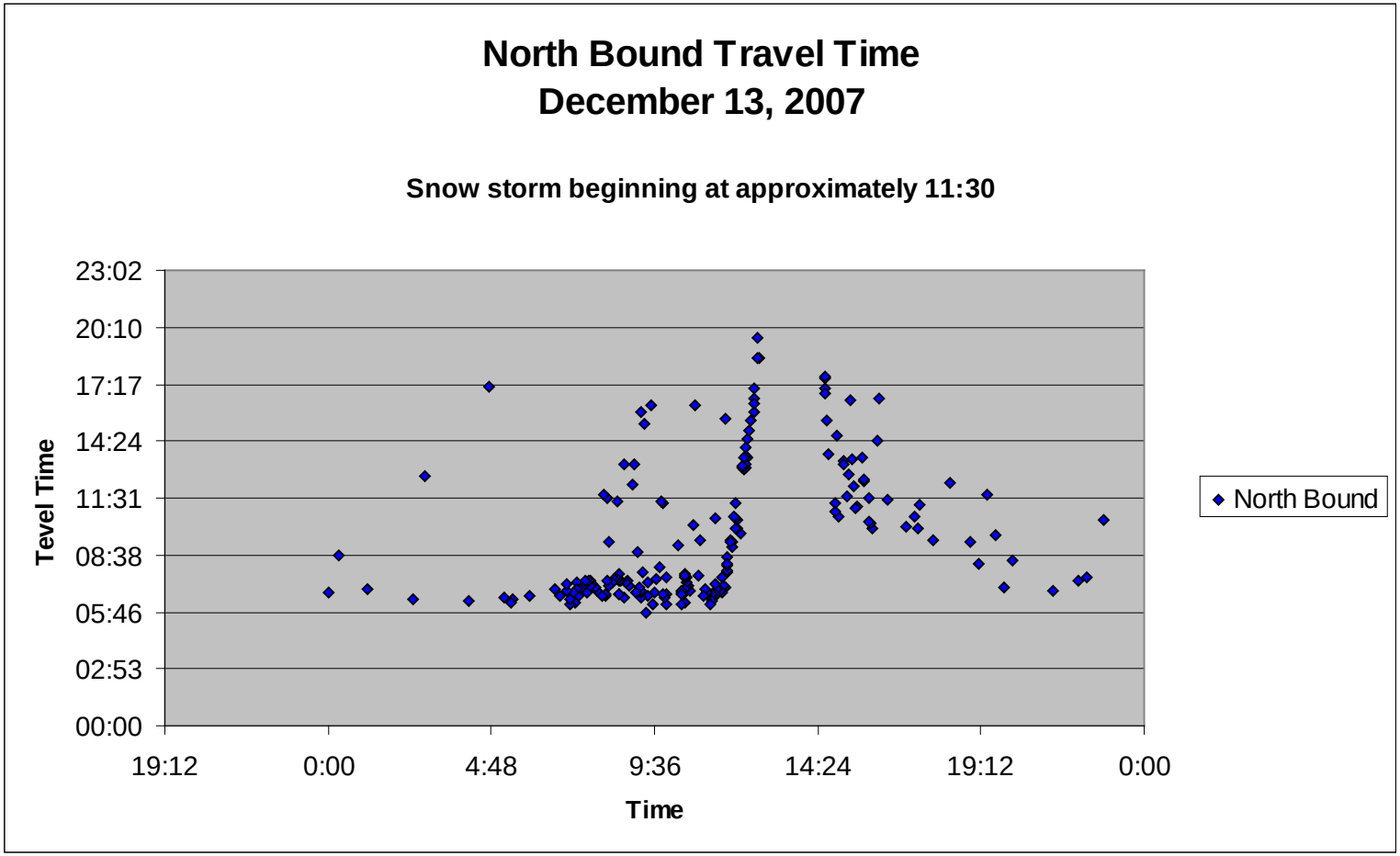
Installation



Travel Time Data

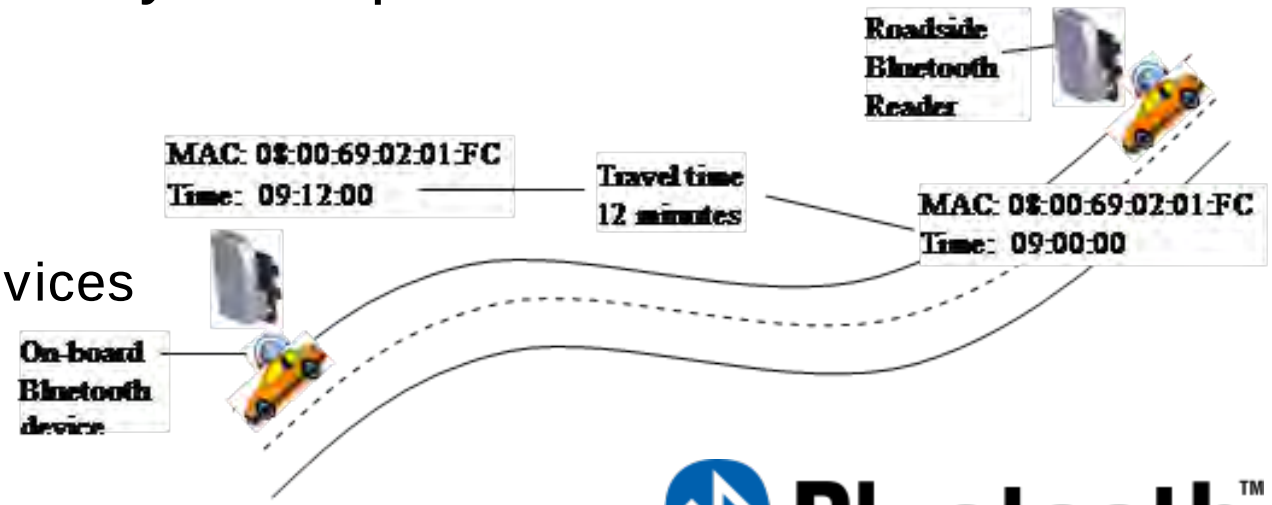


Travel Time Data with Congestion



I-91 Bluetooth Travel Time Estimation

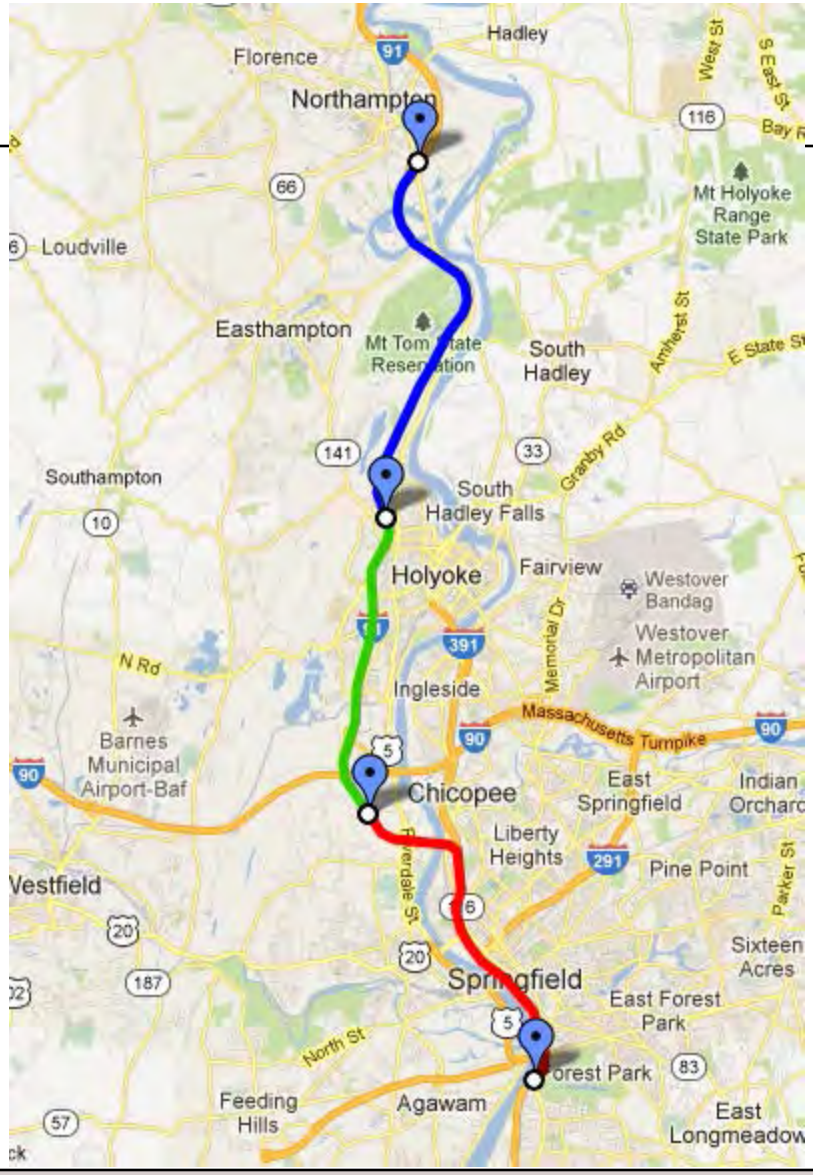
- Similar process to LPR and Toll-Tag
- System detects **discoverable** Bluetooth devices
- **MAC addresses** matching
- Many vehicles carry such probes
  - Phones
  - Computers
  - GPS
  - Hands-free devices
  - Stereos
  - Toys
  - …



Bluetooth™

I-91 Travel Time Study

- Comparing different methods of collecting travel times on a rural highway.
- Commercial data
  - INRIX – Fleet GPS
  - TraffiCast – Bluetooth
- Supporting data
  - Video based license plate matching
  - Floating car
    - GPS
    - License plate



I-91 Travel Time Study Results

- Results of statistical tests for Bluetooth and GPS on different segments.

		BT-GT	GPS-GT	Critical Value
	MAPE	5.48%	3.97%	
Segment 1	t-test	-7.62	-0.99	$\lvert t_{0.025,34} \rvert = 2.02$
	χ^2	48.48	48.51	$\chi^2_{0.05,34} = 48.6$
	MAPE	4.24%	3.33%	
Segment 2	t-test	-5.76	-0.60	$\lvert t_{0.025,33} \rvert = 2.03$
	χ^2	47.34	47.34	$\chi^2_{0.05,33} = 47.4$
	MAPE	5.91%	4.88%	
Segment 3	t-test	-5.72	-0.62	$\lvert t_{0.025,31} \rvert = 2.04$
	χ^2	44.95	44.91	$\chi^2_{0.05,31} = 44.99$

- For a travel time of 7 minutes, an error of 5.5% represents 23.1 seconds.
- How does this error affect our decisions?

Sources

- Collura, John and Carrie W., “Information Technology Innovations in Public Transportation”, Transportation Engineer’s Handbook, M cGraw-Hill, Second Edition, 2011.

- IEEE Intelligent Transportation Systems Society Newsletter
  IEEE ITS Society Newsletter Vol. 16, No. 1, January 2014

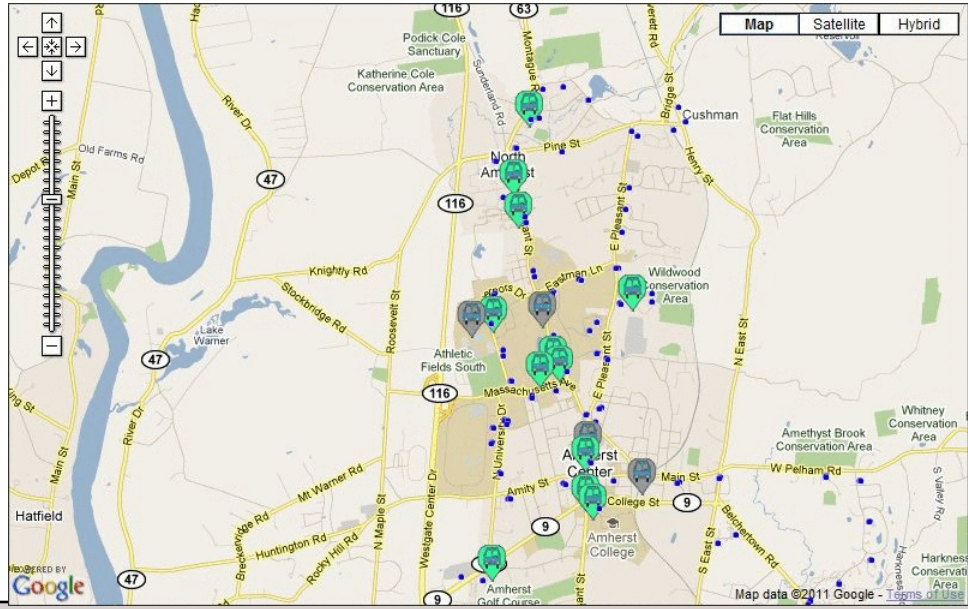
- USDOT Joint Program Office, ITS Program

Closing comments/Questions??

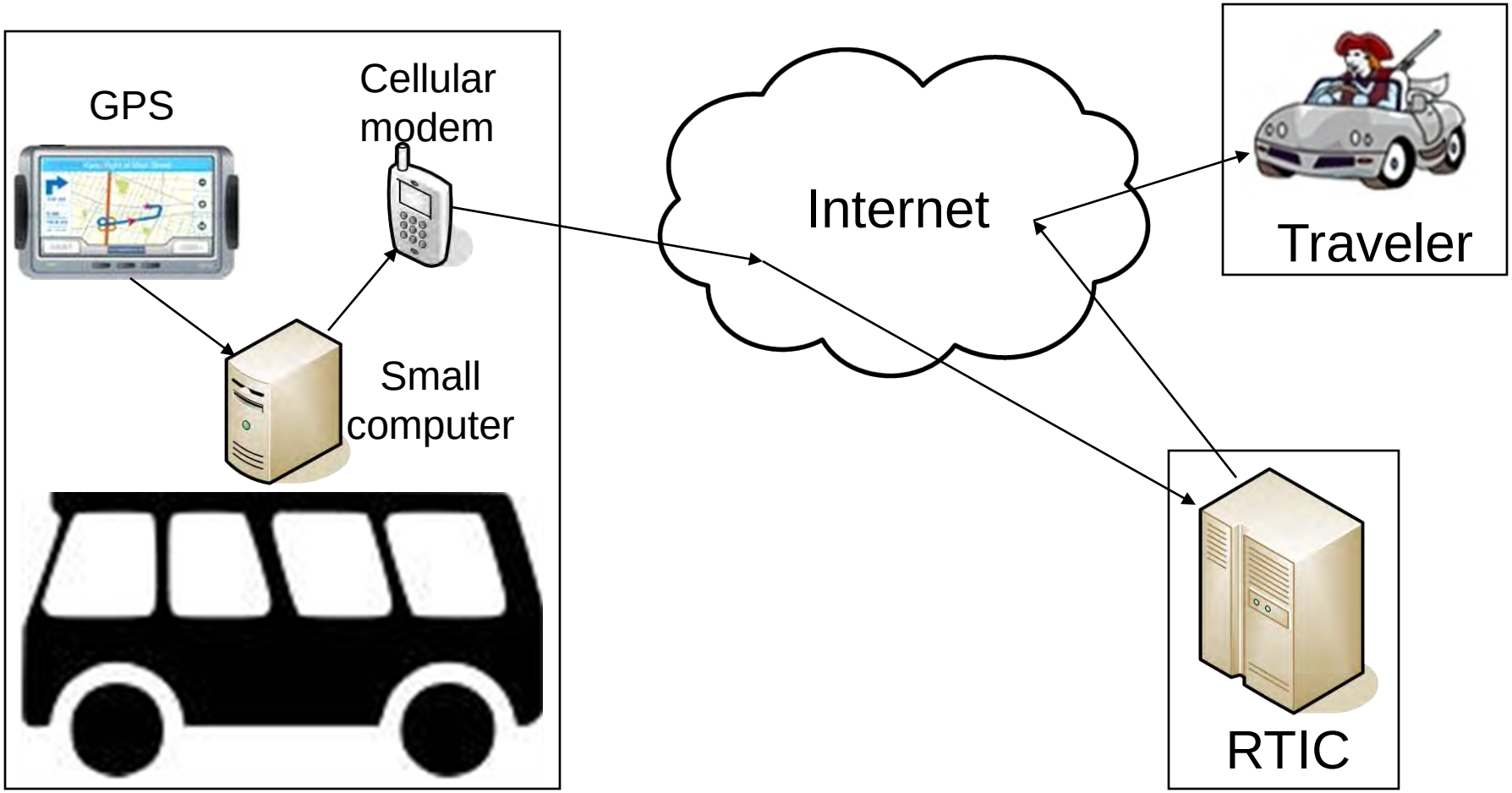
- Transit Management and Operations Certificate Program (Uass Transit, UMTC, FTA, and First Transit, Inc)
- masstraveler.com RTIC website
- collura@ecs.umass.edu

Bus Tracker

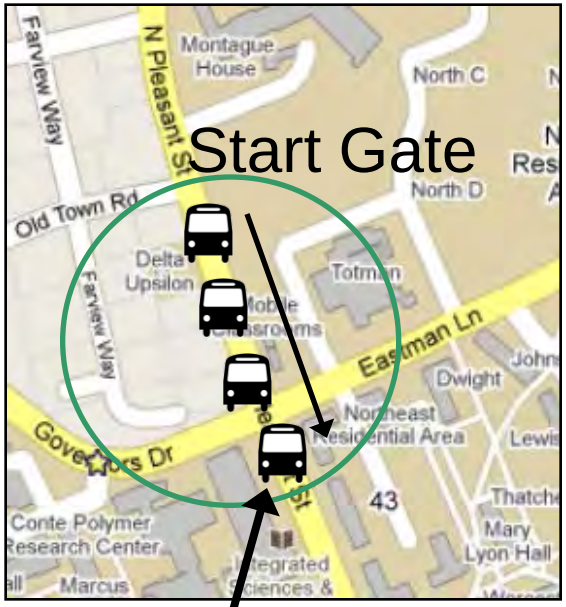
- GPS/computer/cell modem
- Originally a Computer Science DARPA research project
- Data onto a Google Map
  - Bus passengers
  - Dispatchers
- End of life ☹
- New PVTA **AVL**



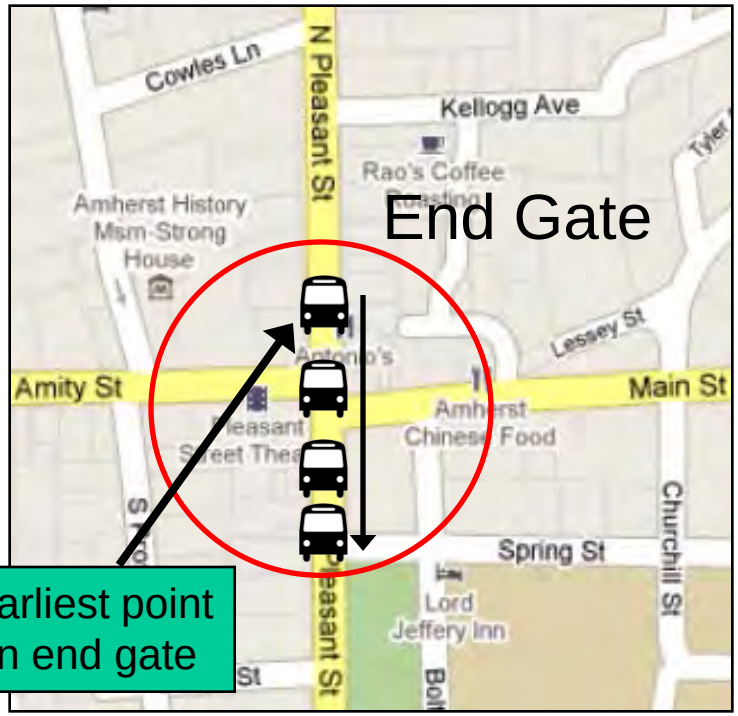
DieselNet/RTIC Topology



Bus Tracker Travel Time Algorithm (single vehicle)



Latest point in start gate



Earliest point In end gate

travel time = selected end point time - selected start point time